

MATING BEHAVIOR AND SPERMATOPHORE MORPHOLOGY
IN THE PSEUDOSCORPION *DINOCHIRUS TUMIDUS*
BANKS (CHELIFERINEA, CHERNETIDAE)¹

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Recent studies on the mating behavior and spermatophore morphology of some European pseudoscorpions (Weygoldt, 1966) have shown a variety of methods of sperm-transfer in this group. All male pseudoscorpions deposit spermatophores from which the females take up sperm. But the means by which sperm-transfer is ensured differ among families and genera. In the more primitive families Chthoniidae, Neobisiidae, Garypidae and Cheiridiidae there is no mating; the females trace the spermatophores chemotactically. The Chernetidae and Cheliferidae, on the other hand, have a courtship dance during which the male deposits spermatophores and leads the female to them. The comparison of different methods of sperm-transfer in pseudoscorpions has led to the assumption of an evolution from simple behavior without mating (*e.g.*, Chthoniidae) to the most complex mating dances (*i.e.*, Cheliferidae). To confirm this assumption, further knowledge of sperm-transfer methods in different species of pseudoscorpions seems necessary. In this paper the mating dance and spermatophore of *Dinocheirus tumidus* Banks are described. This species is of special interest because of its sexual dimorphism. The pedipalpal hand of the male is much stouter than that of the female, being greatly swollen on the inner and dorsal side. It is not known how the male uses this feature.

MATERIAL AND METHODS

The animals were collected at Big Pine Key, Florida, at the end of December, 1965. They occurred in great numbers under pieces of wood in the beach drift line. I collected nearly 30 specimens; only six were females. They were kept in the laboratory with the methods described by Weygoldt (1966). Males and females were maintained separately. Shortly after capture some males were placed with females and mating was observed almost immediately. Their behavior was studied with a dissecting microscope. After a few days all females were pregnant and no further mating was observed.

RESULTS

When males are placed with females they walk around and attack all members of their own species. When one encounters another male, a struggle begins in which each male tries to grasp one or both palpal hands of the other. Then, they pull each other as strongly as possible. This may last for several minutes. Finally,

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they separate and one of them quickly runs backward, showing excited beckoning movements of his pedipalps. Sometimes he is followed a short distance by the other.

The mating behavior

When a male encounters a female, he grasps one of her palpal hands. Sometimes the female tries to escape; then he rapidly grasps both of her hands and pulls her strongly several times. But soon he releases her second hand and holds, for instance, her right hand in his left hand. This is maintained throughout the whole mating dance, during which several spermatophores are deposited and transferred. At the beginning the male sometimes walks around and pulls the female behind him.

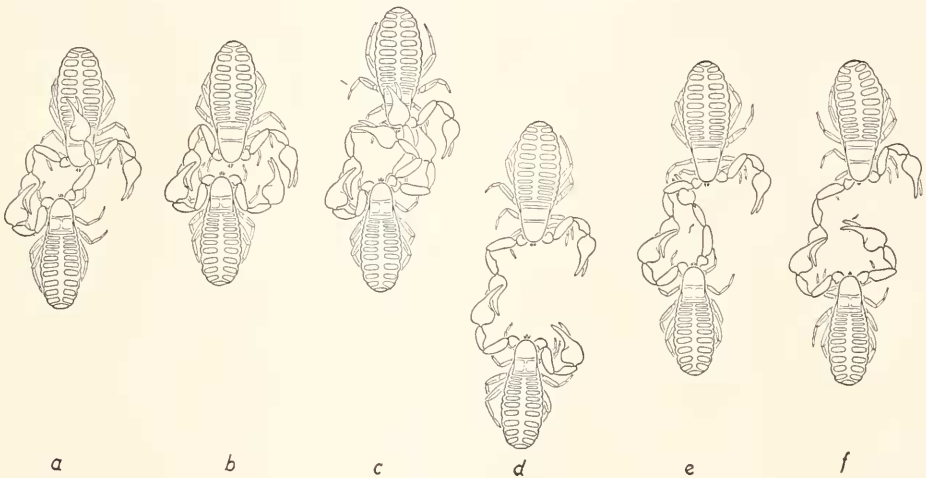


FIGURE 1. The mating dance of *Dinocheirus tumidus*. a: The male (below) touches the back of the female. b: The male begins to deposit the spermatophore. c: The male forms the sperm package of the spermatophore and touches the female with characteristic quick movements of his free pedipalp. d: The male pulls the female towards the spermatophore. e: The male has pushed back the female and now shakes her. He pulls one palpal hand of the female and presses his free hand against the femur of the same female pedipalp. Between mates the stalk of the spermatophore is visible. f: The male pushes down the stalk of the spermatophore. The female bends her opisthosoma and presses her ventral side against the ground, thereby removing the sperm package from her genital opening.

After this he places himself right before the female and the mating dance begins. The male slowly nears the female; she slowly steps backward. Then, he pulls her, forcing her near him, but she again slowly steps backward. Suddenly the male extends his free pedipalp and touches the back of the female with his hand (Fig. 1a). The female immediately stops stepping backward. Now the male shows very characteristic movements with his free pedipalp. He moves his hand above the female and with his fingers touches her back, the upper side of the femur of one of her pedipalps (the hand of which he holds in his other hand), and the under side of her other pedipalpal femur (Fig. 1c). At the same time he steps forward, nearing the female. The female lifts her body and finally stands on extended legs before the male. The male now stops moving his free pedipalp and deposits the

spermatophore on the substratum (Fig. 1b, 2a). At first, when he is secreting the stalk of the spermatophore, the male does not show any movement, and the female begins to step backward. But during formation of the sperm package the male again touches the female. The movements of his free pedipalp become very quick and excited (Fig. 1c). Suddenly he stops. The spermatophore is now formed and the male gradually steps backward over it and pulls the female to it (Fig. 1d). The female follows, at first reluctantly, and then slowly steps over the spermatophore. When her genital opening is just above the spermatophore she takes up the sperm package. At the same moment the male pushes her back with his free hand; the spermatophore stalk without sperm package now becomes visible between mates. Then, he brings his free hand under the femur of her pedipalp which he holds in his other hand. He presses the swollen inner side of his free hand against this femur (Fig. 1e). With one hand pulling the female's hand and with his other

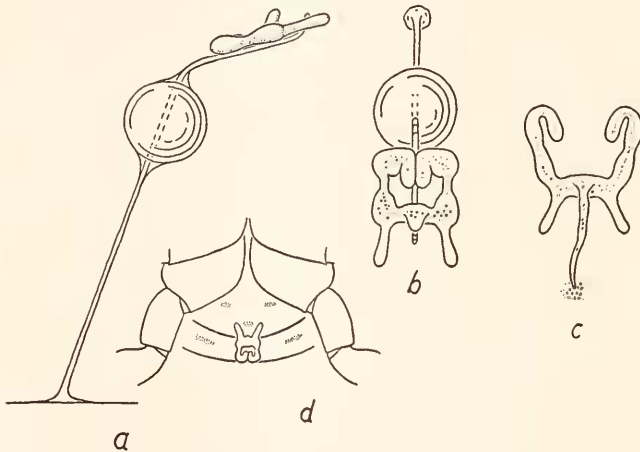


FIGURE 2. The spermatophore of *Dinocheirus tumidus*. a: The spermatophore seen from the side. b: The spermatophore seen from above. c: The sperm package after it is put into water. d: The female genital field with the sperm package. Only the duct of the sperm package has entered the genital opening.

hand pushing the female's femur of the same pedipalp, the male shakes the female with a series of short and quick movements forward and backward.

After these shaking movements the first sperm transfer is finished. The male removes his free hand from the female pedipalp femur and searches for the spermatophore stalk which is still standing between mates. When he finds it he pushes it against the ground (Fig. 1f). Sometimes he does not find it, because it was thrown down by the legs of the female or by some other accident. Then, he pushes other particles to the side that lay between him and the female (e.g., pieces of sand).

During the same time the female moves her opisthosoma. She bends it to the sides and up and down. Especially she presses her ventral side against the ground several times and thereby removes the emptied sperm package from her genital opening (Fig. 1f).

Following this the male again touches the back of the female and the whole process is repeated. The mating dance may last 15 to 30 minutes, and every five to seven minutes a new spermatophore is deposited and transferred.

At the end of the mating dance both mates lie down and rest for 10 to 15 minutes without moving, the male still holding one hand of the female. After this repose they may begin a new mating dance or the female may try to escape, vigorously attacking the male with her free hand until the male releases her other hand. Then, they separate and the female hurries away.

Sometimes the female is not receptive when the first or even the second spermatophore is deposited. In this case the male does not succeed in pulling her over the spermatophore and she does not take up the sperm package. Then, the male does not press the swollen inner side of his free hand against the female pedipalpal femur and does not shake the female. If, after depositing the spermatophore, he does not succeed in pulling the female over it, he waits a short time and then carefully searches and destroys the spermatophore by pushing it down. He then continues the mating dance.

The spermatophore

The spermatophore consists of a stalk, a drop of fluid, and the sperm package (Fig. 2a). The stalk is attached to the ground with a small base. It is about 0.5 mm. high. Since the male moves backward a little when he secretes the spermatophore, the stalk is inclined. Its upper part is bent backward and is nearly horizontal. This horizontal part of the stalk bears the sperm package. Under the sperm package there is a large drop of fluid.

The sperm package consists of two tubes which open into a common duct (Fig. 2b, c). The blind ends of the tubes lie at the anterior part of the spermatophore and are bent backward. From this anterior end the tubes turn to the sides and then backward, joining at the posterior end of the spermatophore. A short distance before their junction each tube has a side branch extending posteriorly. In the newly deposited spermatophore the common duct of the sperm package is short and closed. When the sperm package is put into water, water enters it through the wall, triggering a swelling mechanism. Very quickly the duct elongates until it becomes four to five times longer. At the same time the swelling mechanism inflates the tubes. Now, the sperm package looks like an H, the duct rising in the middle of the crossbeam. Finally the duct opens and the sperm are forced out.

During sperm transfer, when the female takes up the sperm package, only the duct of the package enters the female genital opening, the remaining part of the package staying outside (Fig. 2d). Simultaneously, the drop of fluid is pushed between the tubes of the sperm package. Together with the fluid inside the genital atrium of the female, it triggers the swelling mechanism which elongates the duct and forces the sperm out of the sperm package. The sperm presumably go directly into the receptaculum seminis of the female.

DISCUSSION

Until now the reproductive behavior of two species of Chthoniidae, one species of Neobisiidae, two species of Cheiridiidae, four species of Chernetidae, and two

species of Cheliferidae has been studied. The males of the Chthoniidae, Neobisiidae and Cheiridiidae (Kew, 1930; Weygoldt, 1966) deposit spermatophores without mating, even when females are not present. The females trace the spermatophore chemotactically. In these groups sperm-transfer is ensured by the great numbers of spermatophores deposited. In the two observed species of *Chthonius*, *Chthonius tetrachelatus* and *Chthonius ischnocheles*, and in the *Cheiridiidae*, *Cheiridium muscorum* and *Apocheiridium ferum*, the males not only deposit spermatophores, but also destroy the old ones by pushing them down. In most cases they destroy an old spermatophore before depositing a new one. In both cheiridiids, the females also destroy old spermatophores.

The Chernetidae and Cheliferidae, on the other hand, have a complex mating behavior (Kew, 1912; Vachon, 1938; Weygoldt, 1966). The chernetid male grasps one or both palpal hands of the female and after having made some characteristic movements (e.g., stepping forward and backward several times), he deposits the spermatophore and pulls the female to it. The mating dance of the Cheliferidae is more complicated. The male dances without touching the female, and by following his movements she finds the spermatophore. After this the male grasps the female pedipalpal femora with his hands and with his forelegs assists her in taking up the sperm. In this group a close contact between mates is not established before the spermatophore has been deposited.

Dinocheirus is a chernetid and its mating dance is of the chernetid type. But the display shown by the male is quite different from those of the males of other species investigated. In *Chernes cimicoides*, *Chernes hahni*, and *Lasiochernes pilosus* the male grasps both hands of the female and walks forward and backward with her several times before depositing the spermatophore. Sometimes the male of *Chernes cimicoides* only grasps one hand of the female, but even then he does not show any display with his free hand. Instead, he shows characteristic movements with his first pair of legs, touching the female with it. In *Dendrochernes cynus* (Kew, 1912), the male holds only one hand of the female and strongly displays with his free pedipalp and first pair of legs. He moves his pedipalp in a "remarkable threatening or perhaps beckoning manner." In this respect there is some similarity between the mating dances of *Dendrochernes* and *Dinocheirus*. But the way in which the male of *Dinocheirus* touches the female before and during the formation of the spermatophore, and, further, the way he treats her afterward with the swollen inner side of his hand are remarkable and bear no similarity to the behavior of the other species. An obvious display after sperm transfer has been reported only for *Chernes cimicoides* (Weygoldt, 1966), the male of which slowly "tries to climb" on the back of the female. But this is not comparable to the way the male of *Dinocheirus* shakes the female, at the same time pushing and pulling one of her pedipalps. In the other species both mates rest without movement after the female has taken up the sperm package.

It should be mentioned that there are some species in other genera with a similar sexual dimorphism, for instance *Hesperochernes molcstus*. It would be interesting to know whether these species show a similar display with their hand. It would also be of interest to know how the male of *Mirochernes dentatus* makes use of the anvil-shaped process on the inner surface of his pedipalpal hand.

Another remarkable feature of the mating dance of *Dinocheirus* is the way the

male destroys whole spermatophores or the remaining stalk. This behavior has not been observed in any other chernetid or cheliferid. It resembles in some respects the behavior of some chthoniids and cheiridiids where the male often destroys an old spermatophore before forming a new one.

Also remarkable is the time used for one sperm transfer. In *Chernes* and *Lasiochernes* 10 to 30 minutes are required for the whole process, in *Dinocheirus* only five to seven minutes.

The spermatophore of *Dinocheirus* is of the chernetid type too. At first it seems to be different, but that is only because of the side branches extending posteriorly on the sperm package. The only remarkable difference is the small size of the spermatophore. In *Chernes* and *Lasiochernes* the sperm package is so big that it covers the whole genital field of the female when it is taken up. The sperm package of the *Dinocheirus* spermatophore is much smaller and contains less sperm. Therefore, the female has to take up several sperm packages to fill her receptaculum seminis.

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SUMMARY

1. The mating behavior and the spermatophore of *Dinocheirus tumidus* Banks are described.

2. During the mating dance the male grasps one palpal hand of the female. Then, he shows a characteristic display with his other hand, touching the back of the female. Finally he deposits a spermatophore and pulls the female over it. When she has taken up the sperm package, the male presses the swollen inner side of his free hand against the femur of one of the female pedipalps (the hand of which he holds in his other hand) and shakes the female with a series of short, quick movements.

3. The spermatophore is of the chernetid type. It consists of a stalk, a drop of fluid and a sperm package. Only the duct of the sperm package is introduced into the female genital opening. Then, the sperm package is emptied by a swelling mechanism triggered by the drop of fluid.

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